ADAPTIVE OPTICS FOR THREE-DIMENSIONAL MICROSCOPY, OPTICAL DATA STORAGE AND MICRO-MACHINING

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Many optical techniques that require operational precision on the sub-micrometre scale are adversely affected by the presence of aberrations. These techniques include optical data storage, microscopy and nano-fabrication. A solution to this problem lies in adaptive optics where aberrations are measured and corrected dynamically using an adjustable correction element such as a deformable mirror or a spatial light modulator.

Three dimensional optical memories as potential successors to CD, DVD and the recently introduced BluRay disk technologies. Rather than writing data in a single plane the data are written in a number of layers in a suitable recording substrate. The practical requirement that dry objective lenses must be used combined with the desire to use the highest aperture to minimise the size of the written data means that significant amounts of spherical aberration are introduced, a problem which is exacerbated as one focuses further into the recording medium. All of these aberrations conspire to blur the focal spot, increasing the volume of the written bit, decreasing the resolution of the read-out system and effectively limit the number of usable layers of data in the medium. Using an adaptive deformable mirror, we have compensated aberrations for recording of data, using multiphoton processes, and read-out of data, using a confocal microscope [1].

Such aberration correction can also benefit optical micromachining systems where structures are written deep within material using non-linear processes. For example, the production of three-dimensional microfluidic devices requires the precision machining of channels within the bulk of a substrate. Again, the focusing is affected by aberrations and the depth of accuracy of machining can be significantly increased with the use of adaptive aberration correction.

![Figure 1](image)

Figure 1: a) Confocal microscope x-z scans of a data recording layer at a focusing depth of 100µm in a multilayer medium without aberration correction (left) and with correction turned on (right). b) Structures formed by optical micromachining 80µm deep in the substrate: with aberration correction applied (left) and with aberration correction turned off for part of the machining (right).

Reference